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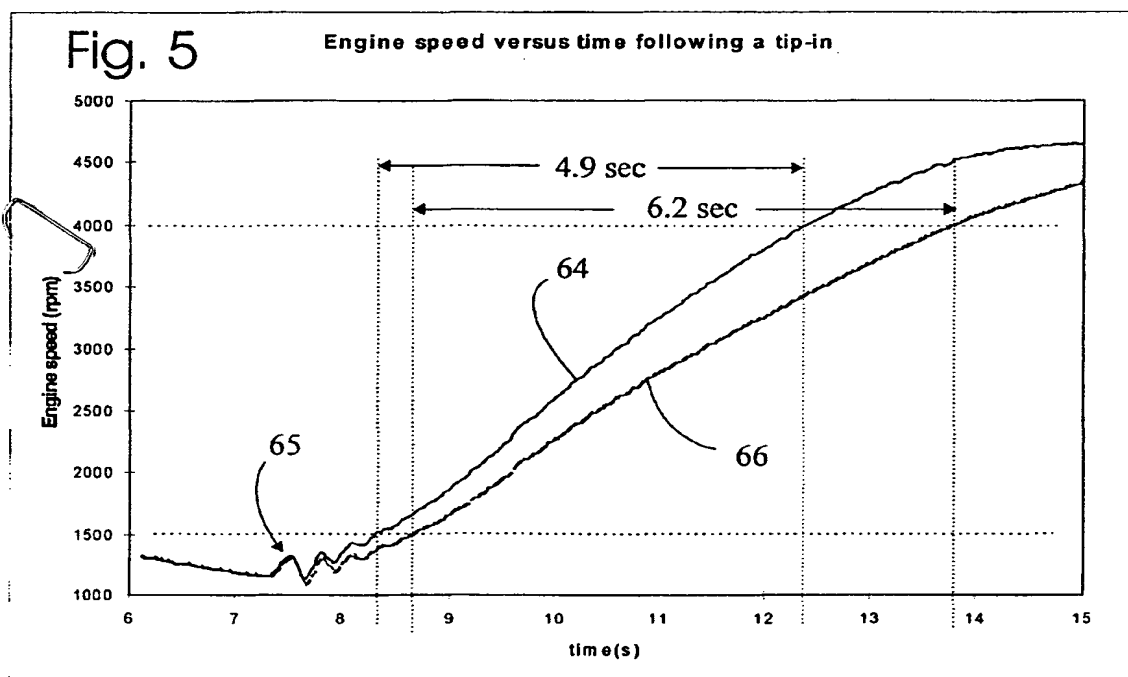
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(54) **Engine management system with torque limit override means**

(57) An engine management system (17) for regulating the quantity of fuel supplied to the cylinders of a diesel engine (11) includes steady state torque limit data (23) indicating, for different engine speeds (24), a torque limit (25) at which the engine is capable of operation for

extended periods. Torque limit override means (39) is arranged to set transient torque limits (31) higher than the steady state torque limits (23) only when the engine is accelerating, whereby increased torque is available during transient operating conditions without compromising durability of the engine.



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## Description

### Field of the invention

[0001] The present invention relates to an engine management system for regulating the quantity of fuel supplied to an engine.

### Background of the invention

[0002] Engine control systems used for the control of diesel engine vehicles limit the amount of fuel injected in given operating conditions to that required to achieve a given torque. The torque limit is established by steady state (constant speed) durability tests on the engine. The test results are converted into a look up table or algorithm stored in the control system so that the system has, for any given engine speed, a torque limit. If the driver sets a demand which exceeds the torque limit at the current engine speed the system controls fuelling of the engine so that the torque does not exceed the stored limit.

### Summary of the invention

[0003] According to the present invention, we provide an engine management system for regulating the quantity of fuel supplied to the cylinders of an internal combustion engine, the management system including:

- a) steady state torque limit data indicating, for different engine speeds, a torque limit at which the engine is capable of operation for extended periods; characterised by
- b) torque limit override means arranged to set transient torque limits higher than the steady state torque limits only when the engine is accelerating, whereby increased torque is available during transient operating conditions without compromising durability of the engine.

[0004] The invention depends on the realisation that any acceleration condition must be transient and that the existence of such a condition can be used to indicate transient conditions during which the engine may be set to higher torque operation without compromising durability.

[0005] The amount of torque increase over the steady state limit may be set using a scaling factor dependent upon acceleration values so that a greater transient torque increase is available during higher accelerations (which, by their nature, exist for shorter periods) than for lower accelerations (which may exist for longer periods). The scaling factor also provides for smooth transition into and out of transient torque increases.

[0006] The invention provides a useful increase in torque and hence maximum power output of an engine when it is needed for acceleration.

### Brief description of the drawings

[0007] The invention will now be described further, by way of example, with reference to the accompanying drawing, in which:

Figure 1 is a diagrammatic plan view of a diesel engine vehicle having an engine management system embodying the invention;

Figure 2 is a block diagram of those parts of the engine management system that are relevant to the present invention;

Figure 3 is a graph showing scale factor (solid line) and increase in fuel limit/torque limit (dotted line) over a test period that includes an increase in driver torque demand (tip-in);

Figure 4 is a graph showing raw engine acceleration and low pass filtered acceleration over the same period as is covered in Figure 4; and

Figure 5 is a graph showing engine speed over the same period as is covered in Figure 4.

### Detailed description of the preferred embodiments

[0008] In Figure 1, a motor vehicle 10 has a diesel engine 11 and front and rear road wheels 12 and 13, respectively. The front wheels are driven by the engine 11 via drive shafts 14 through a change speed gearbox 15.

[0009] The engine 11 has fuel injection equipment 16 controlled by an engine management system 17 via line 18. Signals on line 18 determine the quantity and timing of fuel injection by fuel injection equipment 16 and hence the torque produced by the engine.

[0010] Measuring systems grouped in box 19 receive inputs from a driver demand pedal (accelerator) 20 and from gearbox 15 and provides raw engine acceleration, gear (indicating which gear is selected) and driver demand (based on accelerator pedal position) signals to the engine management system 17 via line 21. Other inputs from vehicle sensors are input to the engine management system 17 via line 22. Although a manual change speed gearbox is described, the invention will work equally well with an automatic gearbox or with a continuously variable transmission.

[0011] Referring now to Figure 2, there is shown in block form the elements of the engine management system that are involved in torque control in accordance with the invention.

[0012] A torque limit lookup table 23 provides data that establishes for any engine speed 24, a steady state torque limit 25. A driver demanded torque lookup table 26 contains data that establishes for any combination of engine speed 27 and accelerator pedal position 28, a driver demanded engine torque signal on line 29.

[0013] Based on vehicle inputs on line 22, other torque limits (for example for traction control purposes) are established in box 30 and are compared in minimum

wins box 32 with torque limit values on line 31. The minimum wins box puts a maximum torque value on line 33.

[0014] Driver demanded torque values on line 29 are input to torque modulation function (box 34) along with other vehicle inputs 35 and the other torque control demands (for example idle torque control) on line 36. The torque modulation function provides for modulated transitions between torque demands to reduce shuffle (undesired higher frequency variations in engine speed due to interaction between the engine, the transmission and the vehicle resulting from sudden changes in torque) and for arbitration between torque demands from different sources. The torque modulation function outputs an engine torque demand value on line 37.

[0015] A clipping function at box 38 clips the engine torque demand value on line 37 so that it does not exceed the maximum torque value on line 33.

[0016] Torque limit override means contained within the dotted line 39 in Figure 2 is arranged to set transient torque limits on line 31 higher than the steady state torque limits set by the torque limit lookup table 23 only when the engine is accelerating.

[0017] The torque limit override means subtracts at 40 the steady state torque limit on line 25 from the driver demanded torque on line 29 and at 41 clips the output of the subtraction to be greater than or equal to zero ensuring that the override function only acts to the torque limit, not to decrease it. The clipped value on line 42 represents excess driver demand above the steady state torque limit.

[0018] The torque limit override means 39 receives a raw engine acceleration signal on line 43 which is input to a low pass filter 44. The low pass filter 44 has a gain input 45. The gain is set from a gain lookup table 46 having data relating gain to the selected gear input on line 47. The gain sets the time constant of the low pass filter so that frequencies at or above the shuffle frequency for the currently selected gear are largely removed (see Figure 4).

[0019] Low pass filtered acceleration on line 48 is multiplied at 49 by a factor on line 50 set from lookup table 51 from selected gear 52 which sets a higher factor in higher gears than in lower gears. Higher factors are required in higher gears to produce a useful and noticeable increase in performance as the torque transmitted by the gears in lower in higher gears than in lower gears.

[0020] The modified low pass filtered acceleration 53 is clipped at 54 to be between zero and one to establish an excess scale factor on line 55.

[0021] The excess driver demand above the steady state torque limit value on line 42 is multiplied at 56 by the excess scale factor on line 55 to give a transient torque increment on line 57. The increment is added at 58 to the steady state torque limit on line 25 to give a transient torque limit on line 31.

[0022] The transient torque limit prevails at minimum wins box 32 unless vehicle inputs require a torque limit lower than the transient torque limit and the clipping

function in box 38 ensures that high torque demands on line 37 are limited by the transient torque limit, not by the steady state torque limit. The output of the clipping function 38 on line 59 is used to control torque actuators in the fuel injection system 16.

[0023] The graphs of Figures 3 to 5 illustrate the operation of the invention during a vehicle test, carried out in second gear, which included 7 seconds of overrun operation followed by a full depression (tip in) of the demand pedal 20. Figures 4 and 5 show an engine acceleration beginning shortly after the seventh second of the test. The raw acceleration signal from line 43 (shown at 60 in Figure 4) is noisy due to inertial effects in the engine and transmission, due to torque peaks produced by successive combustion events in the engine and also due to tolerances in the toothed fly-wheel (not shown) from which engine speed is detected. The low pass filter 44 smoothes out the acceleration signal. The smoothed acceleration signal is shown at 61.

[0024] In Figure 3 the excess scale factor on line 55 (shown at 62) goes to its maximum value of one at tip in and the transient torque increment on line 57 (labelled increase in fuel limit in Figure 4 and shown at 63) goes to its maximum value of 10 units and the fuelling of the engine is increased by a corresponding amount over the steady state limit.

[0025] Referring now to Figure 5, the engine speed 64 (and hence vehicle speed) can be seen increasing (following initial shuffle 65) due to the resulting torque demand to the torque actuators on line 59.

[0026] As the engine speed increases, so does vehicle load and the acceleration decreases. By  $t = 12$  seconds, the acceleration has fallen to a level such that the excess scale factor falls below 1 and the transient torque increase begins to fall. It is negligible by  $t = 15$ , even though the demand pedal is fully depressed.

[0027] A lower pedal demand would result in a lower excess scale factor and a longer period of operation at a transient torque limit.

[0028] Figure 5 also shows at 66 an engine acceleration curve for the same test in the same engine and vehicle combination but using conventional steady state torque limits. The time to accelerate from 1500 to 4000 rpm in 2<sup>nd</sup> gear was 6.2 seconds without torque limit override and was reduced to 4.9 seconds by addition of the torque limit override feature of the invention. An improvement in acceleration of the order of 20% can thus be achieved by use of the invention in suitable vehicles.

## Claims

1. An engine management system for regulating the quantity of fuel supplied to the cylinders of an internal combustion engine (11), the management system (17) including:

a) steady state torque limit data (23) indicating,

for different engine speeds (24), a torque limit (25) at which the engine is capable of operation for extended periods; characterised by  
 b) torque limit override means (39) arranged to set transient torque limits (31) higher than the steady state torque limits (23) only when the engine is accelerating, whereby increased torque is available during transient operating conditions without compromising durability of the engine.

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2. An engine management system as claimed in claim 1 in which the transient torque limits (31) are higher than corresponding steady state torque limits by an amount dependent on acceleration (43), greater increase in torque over the steady state limits (23) being allowed for higher accelerations than for lower accelerations. 15
3. An engine management system as claimed in claim 1 in which the torque limit override means (39) determines from the steady state torque limit (25) and driver demanded torque (29), an excess driver demand value (42) representing the amount by which driver demanded torque (29) exceeds the steady state torque limit (25), the excess driver demand value being combined with a scaling factor (55) and with the steady state torque limit (25) to give the transient torque limit (31). 20 25 30
4. An engine management system as claimed in claim 3 in which the scaling factor (55) is determined from acceleration values (43) and is zero for acceleration less than a predetermined value and one for acceleration values exceeding another higher predetermined value. 35
5. An engine management system as claimed in claim 4 including scaling factor determining means (44, 49, 51, 54) comprising a low pass filter (44) responsive to acceleration values (43) and means (54) for clipping the filtered acceleration values to between zero and one. 40
6. An engine management system as claimed in claim 5 in which the scaling factor determining means (44, 49, 51, 54) is responsive to a gear indicating signal (47) to set a time constant for the low pass filter (44). 45
7. An engine management system as claimed in any one of the preceding claims in which the engine (11) is a diesel engine. 50

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Fig. 1

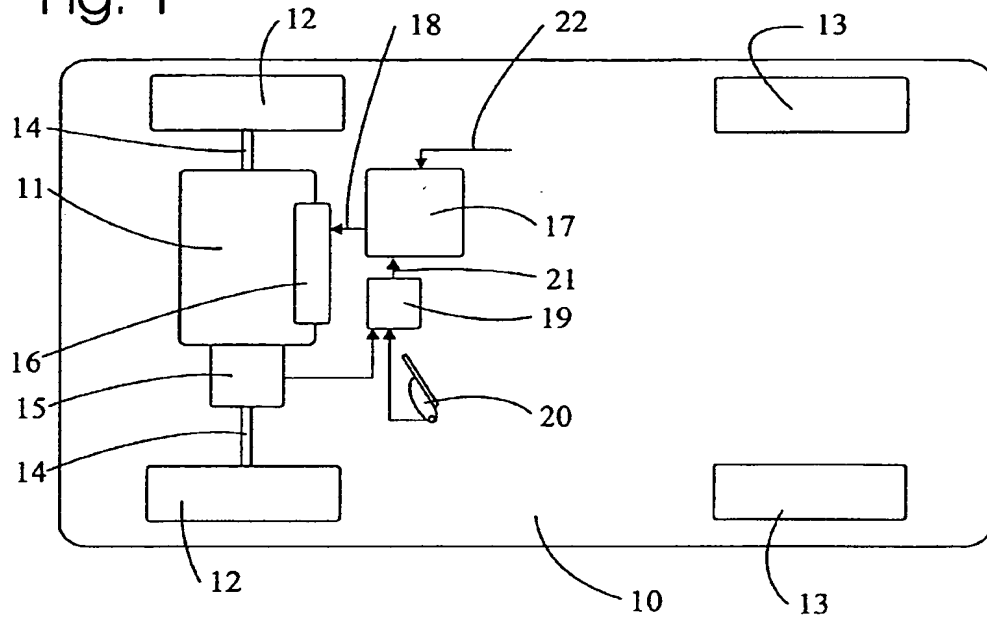
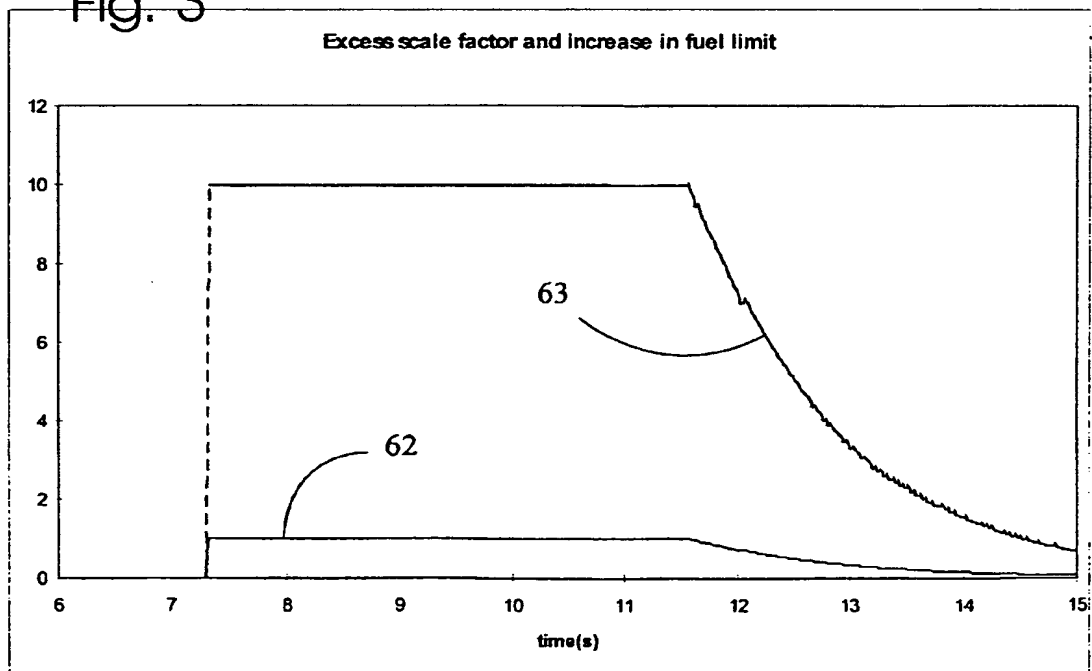


Fig. 3



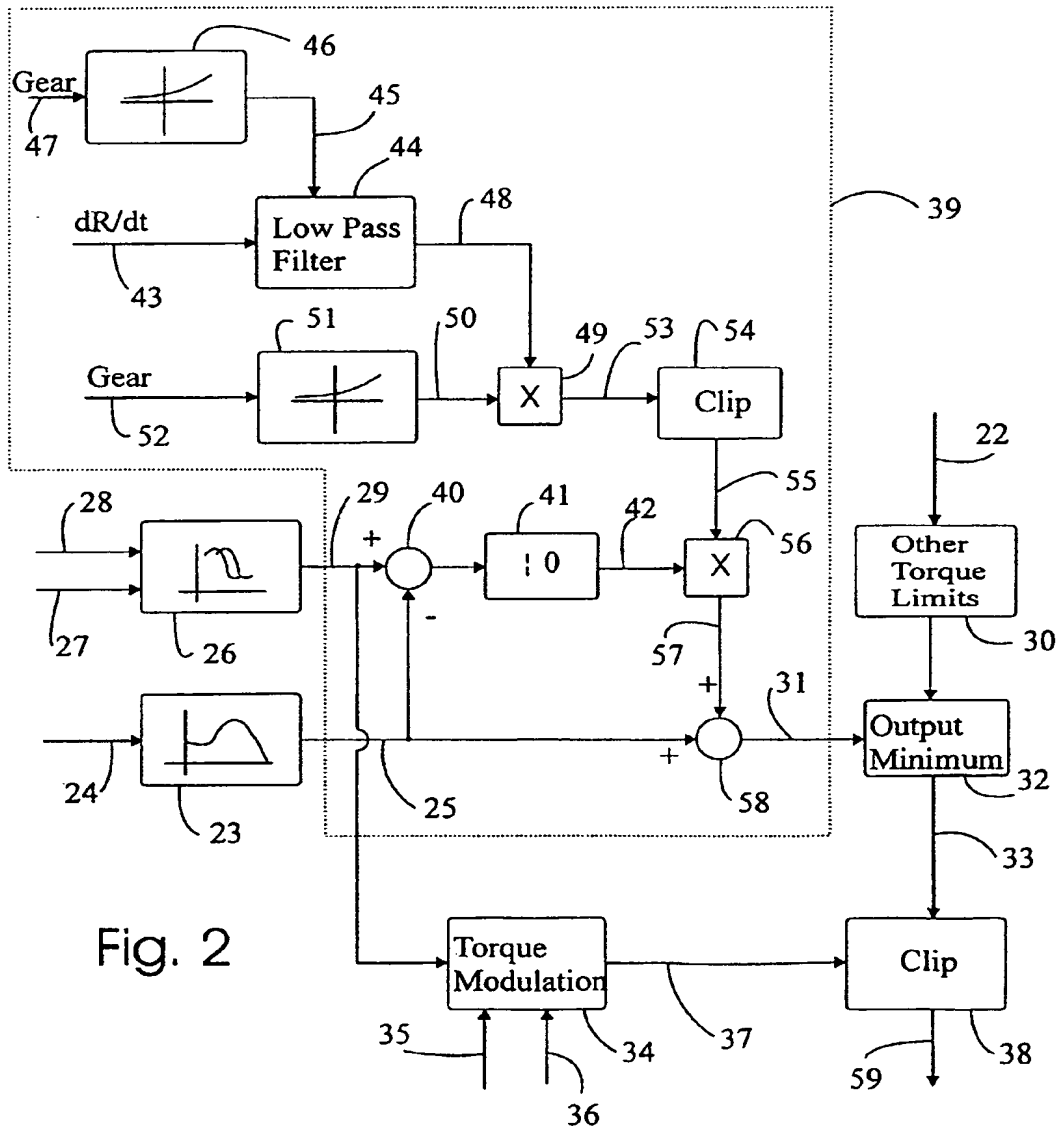


Fig. 4

Engine acceleration and low pass filtered acceleration

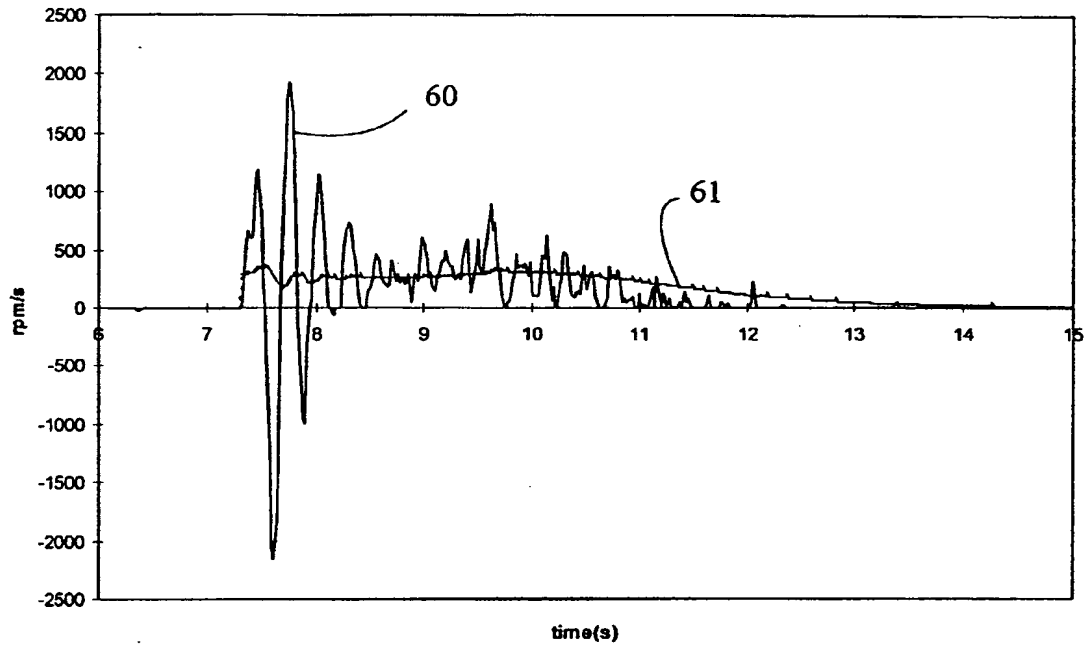
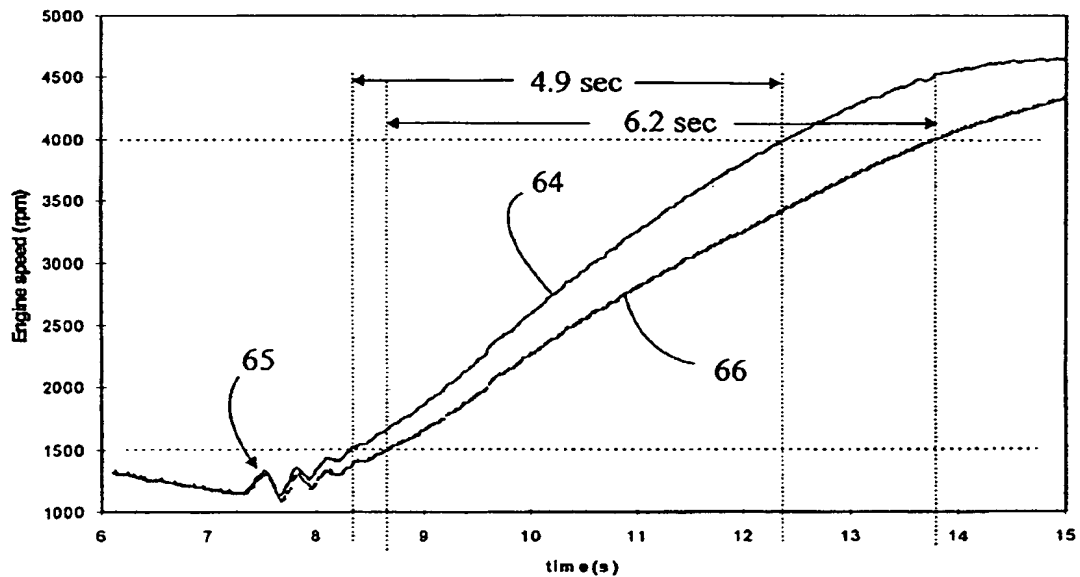


Fig. 5

Engine speed versus time following a tip-in





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Application Number  
EP 99 30 5202

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The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>18 November 1999</b>	Examiner <b>Trotureau, D</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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